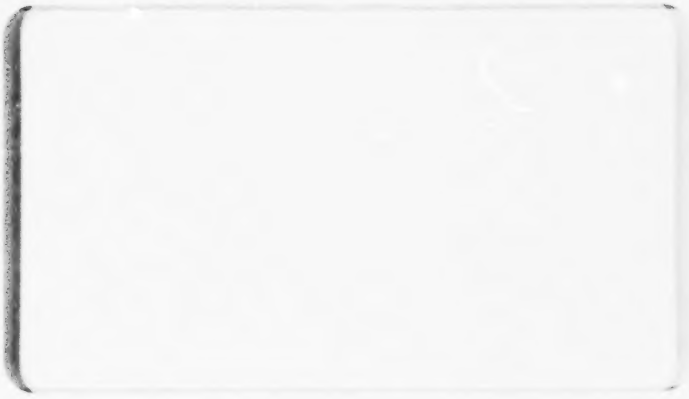
Water Resources



Alberta
ENVIRONMENT

Little Bow River Basin Study

PHASE II: SUMMARY REPORT ON STORAGE FEASIBILITY INVESTIGATIONS

Alberta Environment
Water Resources Management Services
Planning Division

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Investigations on various study components were conducted by consultants referenced in Appendix A. Timely completion of assignments and thorough work were much appreciated.

Alberta Environment staff were involved in co-ordinating and reviewing various study components as follows:

S. Larsen, Planning Division	- Engineering Feasibility - Water Balance Simulations
K. Nelson, Design and Construction Division	- Land Access Agreements
J. B. Kemper, Planning Division	- Highwood River Instream Flow Needs
D. Younie, Planning Division	- Economic Analysis
R. Middleton, Planning Division	- Social Impact - Environmental Impact
J. Carlson, Planning Division	- Public Participation

S. Larsen, L. K. Szojka, J. R. Hart and B. Brassard, all of Planning Division, contributed to the preparation of this summary report.

SUMMARY

The Phase I report on water management in the Little Bow River basin (June, 1985) concluded that storage development in the basin would be the most appropriate means of securing water supplies for existing licencees and for expanding irrigation development. The Phase I study called for completion of feasibility investigations to establish the most advantageous location and size of storage development.

This report summarizes the results of the storage feasibility study and assesses various options for future water management. The study confirms that storage development would provide a secure water supply to meet existing irrigation and municipal needs, allow considerable irrigation expansion and, at the same time, permit higher instream flows along the lower reaches of the Highwood River to improve fish habitat and water quality conditions over those of recent years.

Site 7B1 on the Little Bow River downstream of the confluence with Mosquito Creek is the preferred location for storage development considering engineering, economic, social and environmental factors. Three sizes of storage development at Site 7B1 were considered - 30,000 acre-feet, 50,000 acre-feet and 70,000 acre-feet. Capital costs for these storage developments are estimated to be $8.6 million, $10.5 million and $12.8 million, respectively. (These cost estimates do not include relocation costs for the Little Bow Hutterite Colony and four farmsteads.)

Storage development at Site 7B1 could supply sufficient water for between 22,000 and upward of 50,000 acres of irrigation in the Little Bow River basin, depending on the size of reservoir, the size of the Little Bow diversion canal and the minimum flow requirement on the Highwood River. Considering direct and indirect agricultural benefits alone, storage development would be economically attractive for all combinations of storage size, canal size and minimum flow considered in this study.

The combinations that provide lesser agricultural benefits provide more favourable fish habitat and water quality conditions in the Highwood River. There is strong local support for development of a large storage reservoir at Site 7B1. Storage development would have no major negative environmental impacts.

Deliberations on the appropriate size of storage development should consider available funds, the level of irrigation expansion desired, the minimum flow requirement on the Highwood River and the possibility of upsizing the Little Bow Canal at some future date.

A Local Advisory Committee provided valuable input in the conduct of this feasibility study. The Committee would be a useful vehicle for further input and public liaison for follow-up activities if implementation of the project proceeds.

INTRODUCTION

The Little Bow River Basin Planning Study was initiated in May, 1982 in response to concerns expressed by the public about the supply and quality of water along Mosquito Creek and the Little Bow River in Southern Alberta (Figure 1). The Phase I Summary Report: Inventory was released on August 30, 1985.

The Phase I study concluded that storage development in the Little Bow River basin would be the most appropriate means of securing water supplies for existing licensees and for meeting future needs. A short term plan of action arising from Phase I studies committed Alberta Environment to conducting investigations to establish the most advantageous storage development in the Little Bow River basin considering engineering, economic, social and environmental factors. In addition to meeting existing needs, it was felt that storage development would secure a water supply for considerable irrigation expansion and permit removal of the current moratorium on new irrigation development in the Little Bow River basin.

Four possible storage sites were considered to warrant more detailed investigations: Site LB1 on the Little Bow River near Frank Lake, Site 7B1 on the Little Bow River below the confluence with Mosquito Creek, Site SC2 on Squaw Coulee upstream on the confluence with Mosquito Creek and Site MC4 on Mosquito Creek downstream of the confluence with Squaw Coulee. Several other sites were identified in the Phase I study but were ruled out for various reasons.

Municipal and irrigation water users in the Little Bow River basin depend to a large extent on water diverted from the Highwood River to meet their needs. Under high flow conditions on the Highwood River, diversions to the Little Bow River basin are constrained by the capacities of the Squaw Coulee and Little Bow diversion works. Under low flow conditions, the diversion works have been operated on the basis of informal guidelines which specify the maximum allowable diversion to the Little Bow River basin and minimum flow requirements in the Highwood River. In recent years, water supply shortages during peak demand

STUDY BASIN LOCATION

Figure 1

periods have been experienced in the Little Bow River basin and instream flows in the Highwood River have been inadequate to maintain desirable water quality and fish habitat conditions. Storage development in the Little Bow River basin will provide an opportunity to modify the Highwood River diversion guidelines to provide for more favourable instream flow conditions on the Highwood River. Highwood River instream flow needs are an important consideration in any future decisions related to modifying diversion works or operating guidelines, and storage development in the Little Bow River basin.

SCOPE AND METHODOLOGY

This report provides an evaluation of water storage alternatives and presents possible development and operating scenarios. Technical details are available in the supporting documents listed in Appendix A.

Water management options considered in this report include the development of storage at several alternative sites (Figure 2), rehabilitation and enlargement of the Little Bow Diversion canal, and modifications of the diversion guidelines to provide alternative minimum instream flows in the Highwood River. The Phase I report identified four potential storage sites that warranted more detailed study. The Local Advisory Committee and landowners recommended that one additional site on the Little Bow River, Site 7A, be included in the investigations. It was felt that Site 7A would have less social and transportation impacts than Site 7B1. The planning team supported the request. Options considered were as follows:

- Storage sites and capacities (acre-feet):

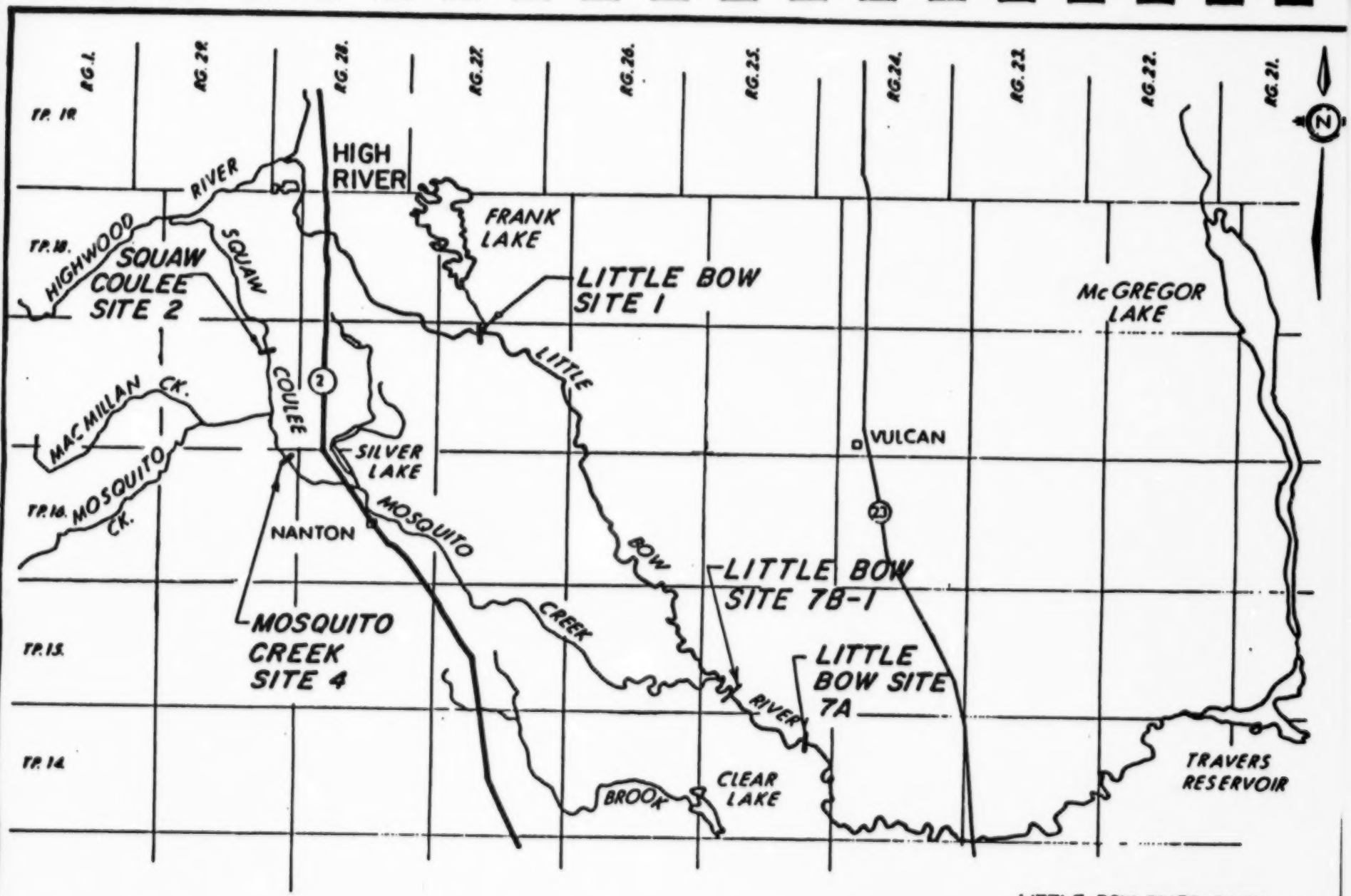
Little Bow 1 (LB1)	17,250
Squaw Coulee 2 (SC2)	14,400
Mosquito Creek 4 (MC4)	21,000
Little Bow 7A (7A)	30,000, 50,000 and 70,000
Little Bow 7B1 (7B1)	30,000, 50,000 and 70,000

- Canal capacity options:

Little Bow Canal	100, 200 and 300 cfs capacities
Squaw Coulee Canal	60 cfs capacity

- Diversion guidelines:

  The maximum allowable diversion rate from the Highwood River to the Little Bow Basin was assumed to be up to the diversion canal capacities (given above), provided that the flow in the



LITTLE BOW RIVER BASIN

POTENTIAL STORAGE SITES

FIGURE 2

Highwood River below the diversion points is not less than, alternatively, 70 cfs, 175 cfs, 250 cfs and fisheries derived minimum flows.

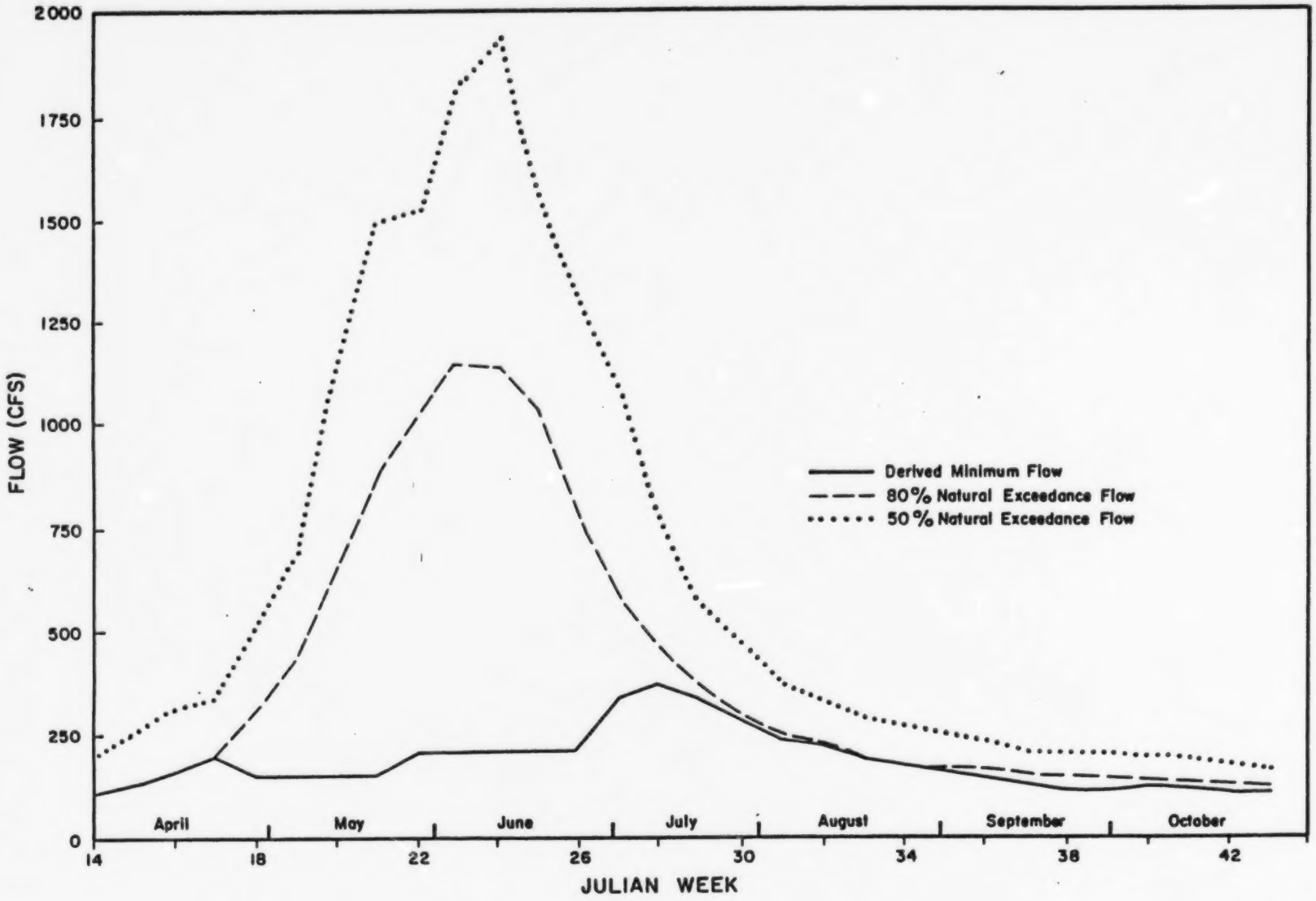
Highwood River fisheries derived minimum flows:
Weekly minimum flows for the Highwood River below the Little Bow Diversion Canal were derived to provide either 80 per cent of optimum fish habitat as determined using a fishery habitat model, or 80 per cent of median habitat that would have occurred under natural flow conditions, whichever was less. The derived minimum flows were no greater than those which would have occurred naturally at least 80 per cent of the time. The minimum flows, shown on Figure 3, are intended to protect the sportsfish population from extreme low flow conditions. The fishery and ecology of the lower Highwood River may not be maintained under continuous operation at these flows.

For each management option, the level of irrigation development that could be supported was estimated using a computer simulation model and irrigation water use patterns of 1984 and 1985. The irrigation acreages determined in this manner must be considered for comparison purposes only. With operational refinements and experience under field conditions, the level of irrigation that could be supported may vary somewhat.

The engineering studies included the following components:

- Hydrology: flood flow and water supply analyses.

- Geotechnical: site geology, reservoir shoreline stability, reservoir water tightness, embankment cross-sections, seepage below embankments, abutment seepage, embankment settlement, spillway and low level outlet foundations, aggregate sources.



HIGHWOOD RIVER BELOW HIGH RIVER

DERIVED SEASONALLY VARIABLE MINIMUM FLOW

FIGURE 3

- Design: reservoir and spillway sizing, site layouts and selection of elements, embankment design, hydraulic design, structural design, foundation and drainage, outlet works, cost estimates.

- Reservoir Costs: land acquisition, roads and bridges, power transmission lines, telephone and gas distribution lines.

Note that farm building relocation costs have not been included in the reservoir cost estimates and, for Sites 7A and 7B1, the costs of relocating the buildings of a Hutterite Colony have not been included. These costs are dependent upon negotiations with each individual landowner. It was felt that realistic cost estimates could not be obtained without prematurely initiating the negotiation process.

A preliminary environmental assessment was conducted for four sites: LB1, SC2, 7A and 7B1. The study considered four categories of environmental resources: soils and surficial geology, land use, water quality, and fisheries and wildlife.

An assessment of impacts on fish habitat and water quality in the Highwood River was undertaken assuming a canal capacity of 300 cfs at Little Bow Canal and 60 cfs at Squaw Coulee, and a 50,000 acre-foot reservoir at Site 7B1.

An assessment of local concerns was conducted for three sites: LB1, 7A and 7B1. Interviews were conducted to collect background information on people living at each site, determine potential landowner impacts, compile landowner views regarding the effect of a reservoir on their operations, and determine landowners' attitudes to multiple uses of a reservoir.

An economic analysis was conducted for various combinations of storage options, canal enlargements, and Highwood River minimum flows. A farm financial assessment for irrigation expansion was also undertaken.

A Local Advisory Committee has worked with the river basin planning team since 1982 in identifying and assessing alternative solutions to water problems in the Little Bow River basin and in conducting the feasibility studies. Committee members are listed in Appendix B.

Water users in the Little Bow River basin depend to a large extent on diversions from the Highwood River. Any development options in the Little Bow River basin that would change the quantity or timing of diversions from the Highwood River would have impacts on instream flows and water quality in the lower Highwood and Bow Rivers, and to some degree, the ability to supply consumptive water needs in the Bow River basin. Instream flow requirements and the impacts of various diversion patterns on fisheries and water quality in the lower Highwood River have been addressed. Matters related to water quality and fisheries in the Bow River and existing and potential uses of water in the Bow River basin will be considered within the context of an overall water management plan for the Bow River basin.

HIGHWOOD RIVER INSTREAM FLOW REQUIREMENTS FOR FISH

The Highwood River supports valuable rainbow trout and mountain whitefish populations. Sufficient quantity of water, of adequate quality, is required year-round to maintain suitable habitat for the various life stages of these species. Adequate flows are needed to accommodate unobstructed upstream spawning migrations by the Bow River rainbow trout population in April, and downstream migrations in May and June. Suitable fry rearing habitat is necessary after late June. Summer rearing and feeding grounds for juveniles and for resident adult trout also need to be maintained, and sufficient flows to ensure overwinter survival are required. Mountain whitefish require enough flow in late summer and fall to provide deep pools for pre-spawning congregation. Adequate flow of well-oxygenated water over riffles is required in the October to April period to ensure egg survival. Since mountain whitefish are resident and highly migratory throughout the Highwood system, flows are needed year-round to provide suitable habitat variety for this species.

The minimum flows to maintain suitable fish habitat were derived using a fish habitat model. Figure 3 shows the derived minimum flows in relation to the natural flows which are exceeded 50 per cent and 80 per cent of the time. Between weeks 18 and 27 (approximately all of May and June), flows under natural conditions are high and the minimum flows represent a relatively small proportion of the flow normally available. Habitat for the sportsfish present in the Highwood River could in fact be improved by reducing flows during the spring spate. After week 28 (early July), flows are lower under natural conditions and the derived minimum flows represent a much higher proportion of the natural flow. Under natural conditions the derived minimum flows would be exceeded between 80 and 97 per cent of the time from July to October. Even small water withdrawals during this period significantly reduce fish habitat.

Existing licenced water users in the Little Bow River basin and along the Highwood River were assumed to have priority over Highwood River minimum flow requirements. Meeting the needs of existing licencees in the Little Bow River basin upstream of potential storage reservoirs and along the lower reach of the Highwood River reduced the frequency with which the minimum flows were met, particularly during late July and August. To provide for more favourable water quantity and quality conditions in the Highwood River during late July and August, it was assumed that only the needs of existing licensed users upstream of potential storage would be met during this period. Any surplus flows beyond the needs of these users would remain in the Highwood River.

STORAGE SITE EVALUATIONS

A brief discussion of the results of investigations at each storage site follows.

Site LB1 - Little Bow River near Frank Lake

Site LB1, with a maximum capacity of 17,250 acre-feet, is located in the upper reaches of the Little Bow River. This site was previously studied by the Prairie Farm Rehabilitation Administration (P.F.R.A.) in 1968. Development at Site LB1 is technically feasible. It would provide sufficient water supplies to meet the needs of the existing development, allow removal of conditions on licenses as well as allow limited expansion of irrigation.

The social impact assessment revealed that there is severe opposition to storage development at the site by the landowners who would be flooded. Members of the High River Hutterite Colony, which is situated immediately below the dam, have also stated their opposition to the site and their preference for storage development near the confluence of Mosquito Creek and the Little Bow River.

Storage development at these sites is estimated to cost about $7.5 million. The economic analysis indicated that there is no particular economic advantage to development at this site over the other possible sites on the Little Bow River.

Site SC2 - Squaw Coulee above Mosquito Creek

The Squaw Coulee Site SC2, with a capacity of 14,400 acre-feet, is located in Squaw Coulee above the junction with Mosquito Creek. Geotechnical investigations revealed possible seepage through bedrock and the abutments, however, development at this location was determined to be technically feasible at a cost of about $7.4 million.

Storage at Site SC2 would support limited irrigation expansion. The benefit-cost ratios were comparable to those for sites on the Little Bow River. From previous investigations, there is known to be landowner opposition to storage in Squaw Coulee and it would impact on a significant archaeological site.

In view of the limited benefits of the project and the reservoir impacts, the Local Advisory Committee recommended that the site be withdrawn from further consideration at this time. This recommendation was supported by the study team.

Site MC4 - Mosquito Creek below Squaw Coulee

The Mosquito Creek Site MC4 would have a storage capacity of 21,000 acre-feet at a cost of about $10.4 million. The site has severe geotechnical limitations. It would also require extensive dyking and relocation of a 500 KV TransAlta Utilities power transmission line running through the reservoir area.

Technical factors, high costs, as well as development limitations resulted in a decision to delete this site from further consideration.

Site 7A - Little Bow River below Mosquito Creek

Site 7A is located on the Little Bow River approximately five miles downstream of the confluence with Mosquito Creek. It has a storage capacity of up to 70,000 acre-feet.

Geotechnical investigations revealed potentially extensive foundation seepage problems due to pervious materials in the foundation and abutments. Also the lack of borrow material for the clay core would result in high construction costs. Site 7A would have lower social and transportional impacts than Site 7B1, and would have similar irrigation expansion potential, however, it is a technically inferior site and should not be considered for implementation.

Site 7B1 - Little Bow River below Mosquito Creek

Site 7B1, with a maximum capacity of 70,000 acre-feet, is located about one mile downstream of the confluence of the Little Bow River and Mosquito Creek. Storage at Site 7B1 is technically feasible, could provide the maximum opportunity for future irrigation expansion and has high social acceptability. Irrigation development would be limited upstream of the reservoir; however, this may not be a major disadvantage to this site in view of the apparent lower level of interest in irrigation expansion along Mosquito Creek and the upper reach of the Little Bow River compared with downstream of the site.

Three storage sizes were considered: 30,000, 50,000 and 70,000 acre-feet. Costs for these various size reservoirs were estimated to be $8.6 million, $10.5 million and $12.8 million, respectively (excluding farmstead relocation costs). Storage site characteristics and impacts for various sizes of storage development at Site 7B1, and for selected canal sizes and minimum flow requirements, are shown in Table 1. Table 1 does not include all combinations of storage size, canal size and minimum flow options that were evaluated in the study. Information on other options is available in the reports referenced in Appendix A.

Almost all of the adjacent and affected landowners support a large storage project at Site 7B1. One family is opposed to a 70,000 acre-foot reservoir because of flooding to their farm house when the reservoir is near its full supply level. There are also four other farmsteads and the headquarters of the Little Bow River Hutterite Colony that would be flooded by the 70,000 acre-foot reservoir; all have expressed support for the project provided they are suitably compensated. There are no affected landowners opposed to the 30,000 acre-foot or 50,000 acre-foot reservoirs, providing compensation is adequate.

TABLE 1

CHARACTERISTICS AND EVALUATION OF STORAGE SITE 7B1

Sec. 5-15-25-4

RESERVOIR SIZE (ac ft)	30,000	50,000		70,000
PHYSICAL FEATURES				
maximum dam height (ft)	63	75		82
dam crest length (ft)	2,100	2,300		2,800
full supply level (ft asl)	3,154.0	3,166.0		3,173.0
reservoir area (ac)	1,420	2,135		2,655
ENVIRONMENTAL IMPACT OF RESERVOIR	minimal	minimal		minimal
SOCIAL IMPACT OF RESERVOIR				
families affected by flooding[1]	42	44		48
farmsteads flooded[2]	4	4		5
families opposed to project	0	0		1
STORAGE COSTS ($ million)				
dam construction	6.08	7.01		8.55
reservoir costs[3]	2.52	3.49		4.28
total storage cost[3]	8.60	10.50		12.83
storage cost per acre foot ($)	286	210		183
DIVERSION CANAL CAPACITY (cfs)[4]	100	100	300	300
canal rehab/enlargement cost	0.75	0.75	0.95	0.95
total project cost ($ million)[3]	9.35	11.25	11.45	13.78
IRRIGATED ACREAGE (ac)[5]				
Highwood River flow constraints				
70 cfs minimum flow	37,500	39,000	50,700	57,000
250 cfs minimum flow	24,300	25,500	41,300	45,300
variable minimum flows[6]	22,800	24,800	39,900	43,900
ECONOMICS				
project cost per acre of irrigation expansion ($)				
Highwood River flow constraints				
70 cfs minimum flow	383	434	304	314
250 cfs minimum flow	834	907	406	428
variable minimum flows[6]	964	962	427	447
benefit - cost ratios (economic/socio-economic)[7]				
Highwood River flow constraints				
70 cfs minimum flow	1.5/2.7	1.3/2.5	1.4/2.6	1.3/2.5
250 cfs minimum flow	1.2/2.3	0.9/1.7	1.2/2.3	1.2/2.3
variable minimum flows[6]		0.9/1.7	1.2/2.3	

Notes:

(1) includes 13 families in the Little Bow Hutterite Colony
(2) the Little Bow Hutterite Colony is considered to be one farmstead
(3) costs for relocation of farmsteads and Hutterite Colony headquarters not included
(4) alternative capacities are for the Little Bow Canal; the existing 60 cfs Squaw Coulee canal is assumed in all cases
(5) acreage includes 13,100 acres of existing irrigation
(6) variable minimum flows are discussed on page 4 and page 8
(7) economic B/C considers only direct costs and benefits; socio-economic B/C considers direct and indirect cost and benefits. Only benefits associated with irrigation development are considered.

There were no significant environmental concerns identified for storage development at this site. The assessment of impacts was limited to the areas within and adjacent to the reservoirs.

From the results of the investigations, Site 7B1 would appear to be the preferred location for storage development in the Little Bow River basin considering engineering, economic, social and environmental factors. This site can take advantage of natural flows from both Mosquito Creek and the Little Bow River as well as both diversions from the Highwood River. It is located immediately upstream of the area of highest irrigation development and demands for future development which will provide for more efficient and effective operation.

A discussion of various storage sizes, canal sizes and minimum flow options follows.

DISCUSSION OF STORAGE OPTIONS AT SITE 7B1

Storage Size

Storage size, canal capacity and minimum flow requirements on the Highwood River affect the water supply that can be made available for consumptive use along the Little Bow River. From the results of the analyses of various combinations of options, some observations on storage size at Site 7B1, in relation to the other two variables, can be made.

If the capacity of the Little Bow Canal remains at 100 cfs, the optimum size of a storage reservoir is 30,000 acre-feet. Increasing the reservoir size to 50,000 acre-feet will permit only about 2,000 additional acres of irrigation. However, if the canal capacity is increased to 300 cfs a 30,000 acre-foot reservoir is too small to take full advantage of this increased water supply. This is particularly evident with the minimum flows on the Highwood River greater than 70 cfs. For instance, with a 30,000 acre-foot reservoir, and minimum Highwood River flow of 250 cfs, increasing the canal capacity from 100 to 300 cfs will permit 3,000 additional acres of irrigation, whereas with a 50,000 acre-foot reservoir, an additional 15,800 acres could be irrigated with the same increase in canal capacity.

If the Little Bow Canal is upsized to 300 cfs capacity at some future date, a 50,000 acre-foot reservoir would be the optimal storage size, regardless of the minimum flow requirement on the Highwood River. The project cost per acre of irrigation expansion is lower for the 50,000 acre-foot reservoir than for either the 30,000 or 70,000 acre-foot reservoirs (Table 1).

If at some future date the diversion from the Highwood River to the Little Bow River basin can be increased beyond 300 cfs via Little Bow Canal and 60 cfs via Squaw Coulee Canal, a 70,000 acre-foot reservoir may have some merit assuming it is desirable to maximize the level of irrigation development in the Little Bow River basin.

Economic Implications of Storage Development

An economic study was carried out to determine the economic and financial feasibility of storage development to provide water supplies for irrigated agriculture. The study focused exclusively on anticipated benefits to agriculture in the Little Bow River basin.

The results indicate that the direct benefit-cost ratios for storage at Site 7B1 range from 0.9 to 1.5, depending on storage size, canal capacity and minimum flow requirements (Table 1). Net present values range from 13 to 15 million dollars. When provincial spinoffs from more intensive agricultural operations are considered (socio-economic analysis), the benefit-cost ratios almost double and the net present values are four or five times larger than the direct net present values. The scenarios with lower agricultural benefits provide higher fishery benefits through more favorable instream flow conditions in the Highwood River.

From a regional perspective, short-term construction expenditures would have a positive economic impact on local communities. It is estimated that 0.9 to 1.2 million dollars would be injected into the local economy over a two-year construction period. In the longer period, this short-term benefit would be dwarfed by the spinoffs from more intensive agricultural operations and related activity in the region.

A financial analysis of on-farm irrigation development in the basin indicates that farm profitability is largely dependent upon a farmer's particular resource base, product mix, management, capital structure, and location/elevation from the Little Bow River. On the whole, the financial analysis does indicate that irrigated agriculture presently has a comparative advantage over dryland agriculture in the study area.

In general, the expected economic rates-of-return for provincial investment in storage development at Site 7B1 compare very favourably with other irrigation development proposals in southern Alberta, both past and present. This comparative advantage stems from the fact that

only direct pumping by local farmers (with no relatively costly distribution system) is being considered such that unit costs are relatively low, and the relative pay-off to irrigation in the Nanton-Carmangay region compared with other regions should be high.

Environmental Implications of Storage Development

The most prominent impact of construction of a reservoir in the Little Bow Basin is the loss of agricultural land. The magnitude of the impact is directly related to the size of the reservoir.

Water quality downstream of the reservoir will probably be improved over existing conditions in the Little Bow River due to the prolonged period of release from the reservoir and higher instream flows during critical water quality periods.

Recreation could be limited by reservoir water level fluctuations. Sport fishing potential will improve downstream of the reservoir and a reservoir fishery could probably be developed. Since there is little wildlife habitat in the valley because of agricultural activities, impacts on wildlife will be slight.

From the environmental overview, there appears to be no major environmental concerns related to storage development at Site 7B1. If more detailed study reveals unforeseen negative impacts, specific mitigation measures could be developed to diminish or eliminate them.

Social Implications of Storage Development

A Local Advisory Committee worked with the planning team in the conduct of the feasibility study. All affected landowners in the potential reservoir areas were interviewed with regard to the impressions and preferences for storage development in the Little Bow River basin. Numbers of landowners affected and homesteads requiring relocation for development at Site 7B1 are summarized in Table 1.

The Local Advisory Committee and almost all affected landowners, including the Little Bow Hutterite Colony, support development of a large storage reservoir at Site 7B1 provided the affected landowners are fairly compensated for loss of land and relocation of buildings. Only one family is opposed to large storage development due to farmstead flooding when the 70,000 acre-foot reservoir is near its full supply level. A 50,000 acre-foot reservoir would have a lesser impact and would be more acceptable to that particular landowner. Four other farmsteads and the headquarters of the Little Bow Hutterite Colony in the reservoir area would require relocation.

Two landowners living downstream of Site 7B1 have requested that their farmsteads be relocated if a decision is made to construct a dam at that site. Their support for storage at Site 7B1 is conditional on adequate compensation for relocation.

A reservoir at Site 7B1 would impact on Secondary Highway 529 and the Alston crossing, two important travel routes. A causeway at Secondary Highway 529 would be very costly ($5.5 million). Relocation of the highway to Alston crossing at a cost of $2.3 million is a locally acceptable alternative and has been included in the project cost estimate.

Operation and Maintenance Considerations

It is anticipated that the dam would be licensed to Alberta Environment and would be operated and maintained by that Department. Operation of the dam and diversions from the Highwood River would consider the needs of consumptive water users, recreational activities, instream flow needs and Highwood River diversion guidelines. Irrigation development along various water supply channel reaches would be carefully controlled through the licensing process to assure that demand does not exceed the water supply capability of the system.

Operation and maintenance of the storage facility is estimated to require one permanent position plus in the order of $50,000 annually (in addition to the staff and cost of operation and maintenance of existing diversion facilities).

Effects on Fish Habitat and Water Quality in the Highwood River

Approximately 3,700 acres of existing irrigation development as well as municipal and other water demands upstream of the reservoir in the Little Bow River basin must be continuously supplied from the Highwood River. These needs, plus existing licensed uses along the Highwood River, were assumed to have priority over minimum flows.

Three alternative minimum flow scenarios were evaluated for their effects on water quality and fish habitat parameters and were compared with natural flow conditions. In all cases, a 300 cfs canal and a 50,000 acre-foot reservoir at Site 7B1 were assumed.

The three Highwood River minimum flow scenarios evaluated were 70 cfs, 250 cfs and fishery derived flow. In the latter scenario, it was assumed that during late July and August diversions to the Little Bow River basin would be restricted to the amount required to meet the needs of existing licencees. Any available surplus flows would remain in the Highwood River to help to provide more favourable fish habitat and water quality conditions.

The three scenarios were evaluated for their effects on two habitat and two water quality parameters. The habitat parameters were the percent of time that the minimum flows were met throughout the diversion season, and the habitat availability in the July through September period (weeks 27 to 39). The July through September period was selected in the latter case as this is the time when habitat restrictions have the greatest effect on fish populations in the river. The month of July and early

August (weeks 27 to 32) are particularly critical to the Highwood River sportfish populations as the river is subject to high temperature and low oxygen conditions. The increased risk of lethal temperature and oxygen levels was determined for each of the three scenarios.

Results of the analysis appear below.

ASSESSMENT OF HIGHWOOD RIVER INSTREAM
FLOW CONDITIONS UNDER ALTERNATIVE MINIMUM FLOW SCENARIOS

	Attainment of Min. Fishery Flows[1] (% of time)	Habitat Availability[2] (% of natural)	Period of Temperature Risk[3] (% of time)	Period of Oxygen Risk[4] (% of time)
70 cfs Min.	31.3	70.5	5.8	46.8
250 cfs Min.	65.9	88.7	5.7	10.8
Fisheries Derived Min. Flows	76.8	91.9	4.0	11.0
Natural Flow Conditions	87.0	100.0	3.2	3.6

1. Percent of time flows are greater than fishery minimum during entire diversion period.
2. Habitat available in scenario as a percent of habitat available naturally from July to September.
3. Temperature stress risk occurs when flows are less than 390 cfs and air temperatures greater than 27°C for three or more successive days in weeks 27 to 32.
4. Oxygen deficit risk occurs when flows are less than 175 cfs in weeks 27 to 32.

The 70 cfs minimum flow scenario is the least desirable in terms of water quality and fish habitat conditions. The 250 cfs minimum flow and the fisheries derived minimum flow scenarios have similar impacts, however the latter scenario has a significantly lower temperature risk and meets the minimum fishery flows more frequently. This scenario would also provide much greater habitat diversity and provide the best protection for fish populations over the long term. It should be noted that all scenarios, with the exception of the 70 cfs minimum, represent significant improvements in conditions for fish over those which have existed for the last several years.

It appears from this preliminary analysis that under natural flow conditions, sportsfish populations in the Highwood River would be at risk from temperature and oxygen stress a small percentage of the time. By satisfying existing licensed demands for water in the summer months, risks to fish are increased. The fisheries derived minimum flow together with allowing the residual flow to remain in the Highwood River in late July and August is the most favourable scenario from a fisheries perspective.

The foregoing habitat and water quality analyses indicate that with storage development at Site 7B1 it is possible to significantly improve fish habitat conditions in the Highwood River compared to the present situation and still meet the water needs of existing irrigators. A significant expansion in irrigated acreage downstream of Site 7B1 can also be realized.

CONCLUSIONS

1. Storage development in the Little Bow River basin could provide a secure water supply to meet existing irrigation and municipal needs, permit considerable irrigation expansion in the basin and, at the same time, permit higher instream flows along the lower reaches of the Highwood River than have been experienced during peak demand periods in recent years.

2. Site 7B1 on the Little Bow River downstream of the confluence with Mosquito Creek is the preferred location for storage development considering engineering, economic, social and environmental factors. All other storage sites considered in this study were less attractive because of engineering and/or social impact considerations.

3. Three sizes of storage development at Site 7B1 were considered. The sizes and their estimated development costs were as follows:

30,000 acre feet	$ 8.6 million
50,000 acre feet	10.5 million
70,000 acre feet	12.8 million

The foregoing cost estimates do not include farmstead relocations. Other factors that could significantly change the cost estimates upon more detailed investigations are:

a) Unforeseen variations in foundation conditions that require modifications to the design of the embankment and/or associated works.

b) Significant changes in the estimate of the probable maximum flood which would require modifications to the spillway design.

4. Storage and water management options considered included the three sizes of storage development at Site 7B1; three capacities for the Little Bow Canal - 100 cfs, 200 cfs and 300 cfs; and four alternative minimum flow requirements on the Highwood River - 70 cfs, 175 cfs, 250 cfs and fisheries derived minimum flows. Depending on the combination of options considered, storage development could supply sufficient water for between 22,000 and upward of 50,000 acres of irrigation in the Little Bow River Basin, which includes 13,100 acres of existing development. Irrigation expansion upstream of the reservoir would be limited regardless of the size of storage reservoir or diversion capacity. Considering direct and indirect agricultural benefits alone, all combinations of storage size, canal capacity and minimum flow requirements considered would be economically attractive. The combinations that provide lesser agricultural benefits provide more favorable fish habitat conditions in the lower Highwood River.

5. There is strong support for a large storage reservoir at Site 7B1 by the Local Advisory Committee and affected landowners provided they receive fair compensation for flooded land and relocation of buildings. One family is opposed to a 70,000 acre-foot reservoir because of farmstead flooding when the reservoir is near its full supply level. Two families living downstream of the reservoir site have indicated that they would want to be relocated if the site is developed.

6. Development of storage at Site 7B1 will not have significant negative impacts on the environment regardless of the size of the reservoir.

7. This report and the reference documents on which it is based provide sufficient information for a decision in principle with regard to storage development in the Little Bow River Basin. If a decision is made to proceed with storage development, follow-up activities, in addition to final design and land acquisition, should include:

a) A drilling program in the reservoir area to firm up the findings of preliminary investigations that concluded reservoir seepage would not be a significant problem. A drilling program to determine the cause of several slides on Mosquito Creek should also be carried out.

b) Development of a water well monitoring program to provide timely identification of changes in water quality and quantity in adjacent wells following implementation of the project.

c) Development of a transportation plan in consultation with Alberta Transportation and local authorities.

d) A review of recreational opportunities and development of a recreation and land use plan so that recreational pursuits on the reservoir can be realized without impacting on adjacent landowners and the primary reservoir uses.

e) Development of operation procedures for the Highwood River diversion works and the storage reservoir considering recreation and instream flow needs on the Highwood River as well as consumptive use needs.

f) Development of a plan for upgrading the Little Bow canal rehabilitation plan in consultation with the Town of High River.

g) Within the context of decisions made for water management in the Little Bow River basin as a whole, assess the feasibility of a gravity diversion to Clear Lake for multipurpose use.

8. The Local Advisory Committee provided valuable input in the conduct of this feasibility study. The Committee would be a useful vehicle for local input and liaison for follow-up activities if implementation of the project proceeds.

Little Bow River Basin Study
APPENDIX A - REFERENCES

Little Bow River Basin Study - Phase I Summary Report: Inventory
Alberta Environment June, 1985

Engineering

- Engineering Report-Canal Rehabilitation and Enlargement
  PFRA April, 1985
- Storage Site Investigation - Conceptual Design Report
  W-E-R Engineering May, 1985
- Feasibility Design Report - Site LB1, SC2, MC4*
  W-E-R Engineering June, 1985
- Confluence Sites - Conceptual Design Report
  W-E-R Engineering August, 1985
- Confluence Site (7B1) - Feasibility Design Report*
  W-E-R Engineering September, 1985
- Little Bow Site 3 - Design Update
  W-E-R Engineering September, 1985
- Hydrogeological Evaluation of the Little Bow Site 7B1
  Piteau Engineering November, 1985
- Storage Site Investigation Site 7A, Feasibility Design Report*
  W-E-R Engineering March, 1986
- Analysis of Water Supply Alternatives
  Nanuk Engineering April, 1986

Economic Assessment

- Economic and Financial Analysis of Irrigation Development
  Marv Anderson and Associates Ltd.
  April, 1986

Social and Environmental Assessment

- Environmental Overview Assessment of Four Potential Reservoir Sites
  Beak Consultants Ltd. July, 1986
- Local Concerns Assessment of Three Potential Reservoir Sites
  Beak Consultants Ltd. July, 1986

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* W-E-R Engineering Ltd. subcontracted the geological/geotechnical component to Thurber Consultants Ltd. and the hydrology component to Nanuk Engineering and Development Ltd.

Little Bow River Basin Study

APPENDIX B - LOCAL ADVISORY COMMITTEE MEMBERS

Name	Representing
Glen Roemmele	Chairman
Gary Flitton	Vice-Chairman
Gordon Jones	M.D. of Foothills #31
Clayton Moncrieff	Village of Cayley
Winn Richards	Town of High River
Colin Laing	(Alternate) Town of High River
Keith Clark	Village of Carmangay
Stanley Munton	Town of Vulcan
Doug McIntyre	Vulcan Fish & Game Association
Eugene Scully	Alberta Fish & Game Association
George Freeman	Ducks Unlimited, Strathmore
Ron Montgomery	Ducks Unlimited, Lethbridge
Dwight Powell	Town of Nanton
A.H. Lockton	(Alternate) Town of Nanton
Lloyd Nelson	M.D. of Willow Creek #26
Ray Harris	O.R.R.P.C.
Barry McFarland	County of Vulcan #2
Hannah McDonald	County of Vulcan #2
Lloyd Annabel	Little Bow Water Users
Roger Ohler	Little Bow Water Users
Gerald Alder	Little Bow Water Users
Lorne Smith	Little Bow Water Users
Ralph Walker	Little Bow Water Users
Bruce Smith	Little Bow Water Users
Bob Christie	Clear Lake
Ian Sundquist	Clear Lake
Neil Ohler	Clear Lake
Rod Coote	Site LB1
Bruce Akitt	Site LB1
Martin Hofer	Site LB1
Evan Williams	Site 7A-7B1
John MacDougall	Site 7A-7B1
Paul DeClerq	Site 7A-7B1
Jerry Strauss	Site 7A-7B1
Hans Lievaart	Site 7A-7B1
Glenn Fath	Site 7A-7B1
Joanne Cummins	Site 7A-7B1

Little Bow River Basin Study

APPENDIX C - RESERVOIR LOCATION PLANS

Site 7B1

- 30,000 ac.ft.
- 50,000 ac.ft.
- 70,000 ac.ft.

Note: Figures prepared by W-E-R Engineering Ltd.